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Research Article

THE EVALUATION OF *HEDGING EFFECTIVENESS* IN INDEX *FUTURE* FOR IRANIAN LIGHT CRUDE OIL PRICE BASED ON MV-GARCH MODELS

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ABSTRACT
In order to the evaluation of hedging effectiveness in this paper we evaluate efficiency of Iran's light crude oil price volatility in one month to four months cross hedge contracts in New York Stock Exchange (NYMEX) using MD-GARCH, BEKK-GARCH, CCC-GARCH, ECM-MD, ECM-BEKK, ECM-CCC pattern. By estimating the optimal dynamic hedge in weekly crude oil price during January 2000 to January 2012, we found that by using MD-GARCH we can cover the volatility risk of Iranian light crude oil through one month to four month NYMEX contracts by 67/85 percent. Among the six mentioned, for futures one month, three months and four months contract CCC GARCH model and for two months, MD GARCH model has the highest efficiency. It should be mentioned that the efficiency of equal position in the cash market and futures (hedge rate 1) is higher than selected strategies in all contracts of one month to four month.

Keywords: *Optimal Hedge Ratio, Futures Contract, Hedging Effectiveness, GARCH*

INTRODUCTION
Oil prices are largely linked to the world economy. This is due to the fact that oil prices affect profitability in different industries because of their high dependence on the petroleum products. Since the beginning of 2003, the price of most of petroleum products doubled, and consequently in the first half of 2008, WTI crude oil price in U.S. reached to $ 145perbarrel, and price of *hedging effectiveness* in index *future* in July 2008 reached to level 147.27 dollars per barrel.
Unlike past oil shocks, mentioned high oil prices due to sudden sanctions and/or supply disruptions, such an increase in prices in viewpoint of some analysts was mainly due to increasing demand for oil in developing countries particularly china and India.
Besides this which mostly put an emphasis on fundamental factors of supply, demand and storage, another group referring to the point that crude oil in other oil markets is no longer a consumer good and turned into an asset class that can be used as a hedge against inflation increase, focused on activities of speculators in the oil futures market as deterministic factor in increase of prices. According to the CFTC in 2008, the trade volume speculation has increased from 37 percent in 2000 to70% in 2008.Major concerns in such circumstances, that is, the trade volume speculation which enters the market, enters the commodity markets as well and then exit, causes higher oil prices and the increased market volatility come to realize.
In such conditions, the performance of financial oil markets, which was before the hedge and price discovery, according to many analysts, disrupted, where again the issue of ***hedging effectiveness*** in index ***future*** for light crude oil price and seeking effective methods for ***hedging*** the risks associated with price was proposed for experts. The main issue lies in the fact that sample refiner seeking to cover the risk of price fluctuations in crude oil market, how and at what rate, has to take step to adopt a proper location in oil futures market so as to minimize the risk existing in market. It should be noted that behavior of crude oil market at this period has not followed the common standard pattern, due to the reasons mentioned above. This study has been proposed regarding two important, but distinctive findings. First, there exists a negative relationship between price of crude oil and natural activities in experimental studies. Second, the behavior of price of a commodity is different from each other in different patterns. In this study, the issue of hedge for an agent hedger like a refiner requesting crude oil is proposed.

Faced with the uncertainty existing in the future price of oil, the position is taken in the futures purchasing market so as to risk driven from changing the oil price minimizes. Optimal hedge ratio is the number of oil futures contracts (1,000 barrels of crude oil) in lieu of the required amount of crude oil refined in the future. This ratio has to be determined to form a refining hedge portfolio, so is highly prioterized.

Economic literature in this context mainly relies on an estimate of the optimal hedge ratio through different econometric models at different commodity markets. In general, the approaches to measure optimal hedge ratio are categorized in two categories: 1-Conventionalpure hedge, 2-The minimum variance hedge. According to the first, the ratio of hedge is assumed equal to 1, where found with not that much application and not used in empirical tasks.

Here, the main reason lies in the fact that risk premium is not considered in this strategy. The minimum variance hedge was proposed for the first by Janson (1960). According to this strategy, selective portfolio risk is minimized. The optimal hedge ratio will be the value which minimizes portfolio risk. According to Markowitz mean-variance portfolio theory (1952), and Martingale-Like Behavior of Prices, it is proved that optimal hedge ratio equals to the covariance ratio between future and cash market returns to variance of future market returns.

Edington and Ashton (1979) proved that optimal hedge ratio obtains from regression of cash market returns to future market returns.

This simple method has been extensively used in upcoming studies. One problem reported in this method which is primarily based on the least-squares estimation method, mentioned obtaining a fixed value for optimal hedge ratio, proposed by Myers (1991).

He believed that joint distribution of cash and future prices changes by the passage of time, thus, the second moment assigned to joint distribution might change as time goes on, whereby a dynamic optimal ratio can be shown for hedge. This problem caused GARCH econometric method, potential at calculating dynamic variance and covariance in models with variance anisotropy, being used to calculate the optimal hedge ratio.

Bailey and Myers (1991) in a study, used multivariate GARCH models, to study hedge efficiency in agricultural commodity markets throughout U.S; this method was then widely spread in financial markets. What prioritized in this newly proposed approach is the very notion of variance-covariance matrix. In this regards, the scholars have proposed a variety of suggestions. Constant conditional correlation GARCH (CCC-GARCH) was introduced by Bollerslev first time in 1990, mentioned one of the common explanations in the preliminary studies. Yet, Constant conditional correlation between future and cash returns given the facts existing in market does not seem logical.

Ding (1994) and Bollerslev (1994) given the time-varying correlation, proposed Matrix Diagonal GARCH model, and then BEKK-GARCH model was proposed by Engle and Kroner (1995), where this was increasingly taken into consideration.

It should be noted that in newer models, variance –covariance matrix is defined in a manner that positive semi-definite theoretical condition always comes true. With the development of these methods, this issue was proposed that which of these methods are more efficient that many studies were conducted in this context. Yet, empirical results on hedge efficiency in models discussed above were all different. Gagnon and Lyon (1995) and Lyon and Puvvala (1998) indicated that hedge using BEKK-GARCH model has higher efficiency than Least-squares regression models for stock indexand interest rates. Bra *et al.,* (1997) obtained a variety of results for futures contracts of commodities market.

Chakrabortya nd Barkvlas (1999) and Lin *et al.*, (2002) obtained the same result where Least squares regression rather than BEKK-GARCH outperforms in terms of hedge effectiveness for stock indices, currencies and commodities. With the development of time series models, the concept of co-integration by Granger (1983) was introduced to be used to examine the long term relationships existing among non-stationary variables like linearity between cash and future prices in hedge models.

Effect ofco-integration in error correction models is implicitly specified. Cho and colleagues (1996) confirm that a error correction model can improve the hedge effectiveness, but, Kroner and Sultan (1993), Park and Switzer (1995) did not agree on this point. This study intends to apply six common models to measure optimal hedge which include MD-GARCH ‹BEKK-GARCH ‹CCC-GARCH ‹ECM-MD ‹ECM-BEKK ‹ECM-CCC, whereby an investigation into effectiveness of such strategies to hedge for Iranian light crude oil price would be provided, and the best strategy would be recognized at this framework.

It should be noted that hedging the price of crude oil is highly highlighted for oil-exporting countries, because such countries generally encompass the types of economy which its trade and financial balance highly relies on exogenous variable in the price of crude oil, and uncontrollable

Movements of this variable negatively affect production, inflation nd economic situation of these countries. This study has been provided in five sections; first section proposes the importance of risk management at energy markets as well as a summary of hedge literature. Second section proposes the theoretical decision making models based on hedge and estimate of hedge effectiveness. Third section consists of a preliminary analysis of price and returns data at cash and future market. Fourth section proposes a report from the empirical results for effectiveness of hedge for Iranian light crude oil price. Fifth section proposes the results.

Hedge Strategy and Methodology

In this part, a variety of hedge models is examined. Considering the existing limitation in simple regression models, six common econometric models have been used, which can be classified in two groups. The first group consists of multivariate GARCH family, MD-GARCH‹BEKK-GARCH and CCC-GARCH. The second group consists of error correction models, ECM-MD‹ECM-BEKK and ECM-CCC. It should be noted that transaction costs are not considered to simplify the estimation process. After the optimal rate of dynamic hedge estimated, the criterion of effectiveness of hedge using different techniques on hedging effectiveness in index future for Iranian light crude oil price would be measured and the best strategy would be then recognized. However, before the empirical issues provided, the method proposed as well as the criterion of effectiveness of hedge existing in the literature review, would be discussed.

Hedge Strategy

Mean-variance Hedgeratio was introduced for the first time by Johnson (1960), Ederington (1979). According to this pattern, the optimal hedge ratio minimizes the variance of portfolio. Considering $RS_t \, and \, RF_t$ as returns in cash and future market at t period, then it can say that the optimal hedge ratio(h) equals:

$$h = \frac{\sigma_{sf}}{\sigma_f^2} = \rho \times \frac{\sigma_s}{\sigma_f}$$

According to the expression shown above, σ_{sf} has been covariance of $RS_t \, and \, RF_t$, and σ_f^2 is the variance of RF_t, whereρ, σ_f, σ_s is correlation coefficient, standard deviation, and cash and future returns. Constant variance –covariance hypothesis causes a constant value obtains for optimal hedge value. An estimate of this value using conventional least squares regression would be easily obtained.

$$RS_t = \mu_1 + \mu_2 RF_t + \varepsilon_{s,t}$$

According to the expression shown above, $\mu_1 \; and \; \mu_2$ are the regression parameters. μ_2 coefficient has been measured using ordinary least squares (OLS), and is the very value for optimal hedge ratio. Yet, practically a potential problem which lies in this simple method, that is, Autoregressive Conditional Heteroskedasticity (ARCH) observing usually in data of financial markets, is not taken into account. Such observations seem that assumptions of classical linear regression models based on homogeneous variance reject error sentence, and leads to finding an inefficient estimate by means of this method. It seems that models from GARCH family can be a better alternative for observing such a situation.

Multivariate GARCH models:

A general form from Multivariate GARCH models as follows is defined in measuring optimal hedge ratio:

$$RS_t = \mu_{11} + \mu_{12} RF_t + \theta_1 \varepsilon_{s,t-1} + \varepsilon_{s,t}$$

$$RF_t = \mu_{21} + \mu_{22} RS_t + \theta_2 \varepsilon_{f,t-1} + \varepsilon_{f,t}$$

$$\varepsilon_t = \begin{bmatrix} \varepsilon_{s,t} \\ \varepsilon_{f,t} \end{bmatrix} \Bigg\| \Omega_{t-1} \approx N(0,H)$$

$$H_t = \begin{bmatrix} \sigma^2_{s,t} & \sigma^2_{sf,t} \\ \sigma^2_{sf,t} & \sigma^2_{f,t} \end{bmatrix}$$

According to this expression, H_t which is a 2*2 matrix is the very conditional variance-covariance matrix, and$\sigma^2_{s,t}$, $\sigma^2_{f,t}$ and $\sigma_{sf,t}$ is the variable variance for cash and future returns and covariance on returns. $\Omega_{t-1}$is the series of information at t-1 period of time. $\varepsilon_{s,t-1}$And$\varepsilon_{f,t-1}$ is the moving mean from degree 1, generally shown with MA(1), and is used at time series to study the serial correlation of the independent variables in the regression. Given multivariate GARCH models, the second moment of the joint distribution of the variables changes over time; Hence, forms of heteroskedasticity for the variance in error sentences at Ordinary least squares models can be explained in this way; Different explanation for $\sigma^2_{s,t}$, $\sigma^2_{f,t}$ and $\sigma_{sf,t}$ dynamism would be discussed in upcoming sections. Given these formulas, the varied hedge ratio to simplicity by means of H_t matrix elements can be explained.

Model of MD-GARCH

To confirm the definite covariance matrix, Ding and Engel (2001) proposed that Ht matrix can be estimated as follows by means of Cholesky analysis:

$$H_t = KK' + AA' \otimes \varepsilon_{t-1}\varepsilon'_{t-1} + BB' \otimes H_{t-1}$$

In this equation, $\otimes$ is Hadamard multiplication or the very element-by-element multiplication. K, A and B matrices have been lower triangular matrices, and then KK', AA' and BB' are positive semi-definite matrices. Here, according to the determination of parameters given existing limitations, the parameters are used to define the lower triangular matrices and positive semi-definite matrices.

Model of BEKK-GARCH: this model similar to Diagonal Model would have positive semi-definite variance covariance. This model has been defined by Engle and Kroner (1995).

$$H_t = KK' + A\varepsilon_{t-1}\varepsilon'_{t-1}A' + BH_{t-1}B'$$

Matrix K has been lower triangular matrices and matrices A and B are the square matrices without limitation. It can prove that diagonal Model mentioned above confirms the positive semi-definite variance covariance. Furthermore, because the bilateral effects are taken in range of $\sigma^2_{s,t-1}$, $\sigma^2_{f,t-1}$ and $\sigma_{sf,t-1}$, BEKK-GARCH model outperforms Diagonal Model(MD-GARCH).

Model of CCC-GARCH

Bollerslev (1990) proposed that H_t is a constant conditional correlation matrix and a diagonal model of standard deviation, where Parsimony of parameters is analyzed as follows:

$$H_t = \begin{bmatrix} \sigma^2_{s,t} & \sigma_{sf,t} \\ \sigma_{sf,t} & \sigma^2_{f,t} \end{bmatrix} = \begin{bmatrix} \sigma_{s,t} & 0 \\ 0 & \sigma_{f,t} \end{bmatrix} \begin{bmatrix} 1 & \rho \\ \rho & 1 \end{bmatrix} \begin{bmatrix} \sigma_{s,t} & 0 \\ 0 & \sigma_{f,t} \end{bmatrix}$$

According to this equation, ρ is the correlation coefficient ranging from $\varepsilon_{s,t}$ to $\varepsilon_{f,t}$, assumed that this value is always constant. This strategy transforms multivariate time series to univariate time series, and then univariate GARCH is applied for each of univariate time series. Constant correlation matrix not only increases computational efficiency but also facilitates the identification of positive semi-definite covariance matrix. Error correction model (ECM): Error correction model is a dynamic model in which the price of goods that are non-stationary connects to each other through along-run equilibrium relationship. Given that co-integration might help for better understanding of cash and future prices in nature, a bivariate error correction model using GARCH error structure based on Engel–Granger is estimated.

Conditional mean equation regarding Engle, R. and K. Kroner(1993) is as follows:

$$RS_t = a_0 + a_1(\ln S_{t-1} - \ln F_{t-1}) + \varepsilon_{s,t} + \theta_1\varepsilon_{s,t-1}$$

$$RF_t = b_0 + b_1(\ln S_{t-1} - \ln F_{t-1}) + \varepsilon_{f,t} + \theta_1\varepsilon_{f,t-1}$$

According to equations shown above, S_{t-1} ,F_{t-1}indicate cash and future price, respectively. Co-integration sentence $(\ln S_{t-1} - \ln F_{t-1})$ indicates dynamic short-term deviations from the long-term equilibrium.

It is supposed that H_t matrix for the series of equations from model MD-GARCH, BEKK-GARCH and CCC-GARCH can be measured as mentioned above.

Measurement of hedge effectiveness: hedge aims to reduce the variance of portfolio returns. A common criterion mentioned effectiveness of hedge to measure the percent of risk decrease, proposed by Ederington (1979) as follows:

$$HE = \frac{\sigma_{R_u} - \sigma_{R_h}}{\sigma_{R_u}}$$

Given the expression above, R_h is portfolio returns which equals to $R_h = R_s - h \times R_f$ and R_u is the return at cash market in situation with lack of hedge. Hence, σ_{R_h} and σ_{R_u} are the standard deviation for hedging portfolios and not hedging portfolios in the given period. Given that hedging seeks a homogenous efficiency for portfolio, lower variance for returns is desired more in the given period. According to the expression above, the more HE gets close to 1, the degree of effectiveness of hedge would keep increasing.

Characteristics of Time Series Data

In this study, effectiveness of hedge is examined. For this, huge Iranian light crude oil prices and one to four months future contracts at Naymax stock exchange have been extracted from database of U.S. Energy Information Administration during period of time 2000-2010.

It should be noted that Iranian light crude oil unlike other crude oils is not transacted and just can be sold based on term contracts. According to such contracts, the crude oil is sold out based on the specific pricing formula.

In this regards, the price of crude oil equals to the price of marker crude. Furthermore, a differential which reflects the difference on quality and difference on supply and demand differs in different period of times.

Figure 1 indicates the procedure for Iranian light crude oil price and the price of one to four months future contracts at Naymax stock exchange.

This figure indicates a strong co-integration between Iranian light crude oil price and the price of one to four months future contracts at Naymax stock exchange.

Furthermore, this figure indicates that a long-run equilibrium relationship exists between such variables.

The reason for difference on the variables derives from lack of short-run equilibrium relationship between supply and demand as well as difference on quality of Iranian light crude oil and WTA. Descriptive statistics for Iranian light crude oil price and the price of one to four months future contracts at Naymax stock exchange have been shown in table 1.

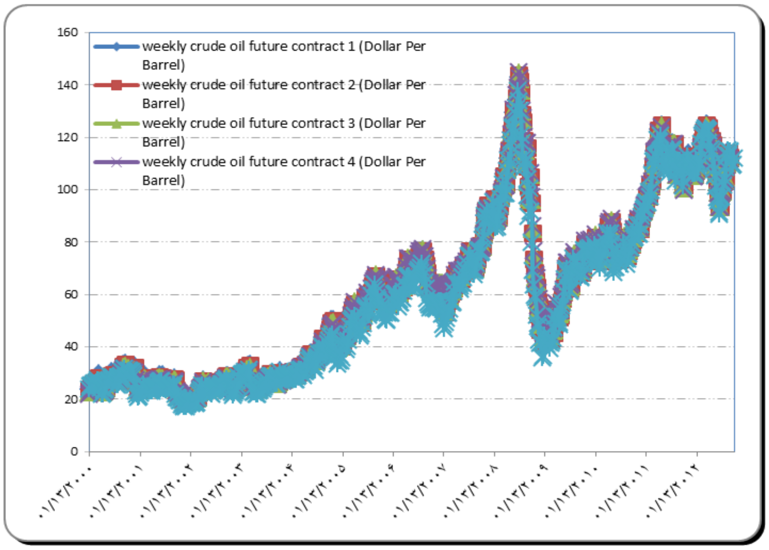

Figure 1: The procedure for Iranian light crude oil price and the price of one to four months future contracts

Table 1: Statistics of changes at cash and future prices logarithm

	Mean	Variance	Diagonal	Skewness	*Jarque–Bera test*	Liang – Box(Q)	Pp of level	Pp of level and procedure	Pp of first difference
Cash price	0/002487	0/0432	-0/516	4/34	74/60 (0/00)	22/871 (0/00)	1/056 (0/924)	-2/8 (0/197)	-20/58
Future one month	0/002480	0/0403	-0/787	4/85	153/59 (0/00)	25/112 (0/000)	1/99 (0/93)	-2/65 (0/2574)	-20/45
Future two month	0/002513	0/0380	-0/759	4/94	158/34 (0/00)	25/353 (0/000)	1/149 (0/936)	-2/59 (0/284)	-20/46
Future three month	0/002561	0/0365	-0/695	4/68	123/68 (0/00)	25/225 (0/000)	1/217 (0/943)	-2/545 (0/3063)	-20/54
Future four months	0/002608	0/0353	-0/649	4/52	104/13 (0/00)	25/282 (0/000)	1/264 (0/948)	-2/477 (0/3398)	-20/55

As shown, the changes in prices are huge for Iranian light crude oil price and the price of one to four months future contracts like the returns of total financial assets, where mentioned with negative deviation and excess Skewness. This result is confirmed with Jarque–Bera test which tests normality of variable distribution.

This statistic indicates a significant deviation of normal distribution for variables. In addition to the unconditional fluctuation, the changes in crude oil price calculated with standard deviation, have been reported equal to 0.208. in general, it seems that returns on future prices have lower fluctuation compared to physical crude oil price. Liang – Box (Q) statistics which is used to test autocorrelation of series, indicates the serial autocorrelation for time series on returns. Engel test (1982) also shows a significant effect of ARCH given conditional variance anisotropy. Eventually, Phillips–Perron test has been used to test unit root. This statistic shows that the price of crude oil and future contracts are not stationary and their first difference is stationary. Such a feature for variables comes along with justifying the use of VECM-GARCH methods to calculate diagonal hedge. As mentioned, use of future contracts to hedge is a necessary act which needs to apply on price of goods. The value of correlation on Iranian light crude oil price and the price of one to four months future contracts equals to 0.999, 0.998, 0.997 and 0.996. Degree of correlation on single cargo market returns and future returns indicate the extent of effectiveness of hedge on future contracts in reducing the single cargo goods portfolio and future contract at the times the constant hedge ratio used.

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Model Estimation

To measure the optimal hedge ratios, two groups have been used, the first group consists of multivariate GARCH family, MD-GARCH‹BEKK-GARCHand CCC-GARCH. The second group consists of error correction models, ECM-MD‹ECM-BEKK and ECM-CCC. The results of estimation for optimal hedge for each type of four-type contracts in form of six methods have been shown in figures 2-5. As observed, the range of changes to optimal hedge ratio for one to four months future contracts equals In general, due to the fact that the fluctuations in crude oil price in the first decade of 21th century reported higher than past, the dynamic hedge rate reported higher than the past. Lower bound of this range is related to the recent global financial crisis, transferred to the oil markets as well. In following, comparing effectiveness of hedge using the strategies to calculate the optimal hedge ratio using one to four months future contracts at Naymax stock exchange has been discussed.

Figure 2. optimal hedge ratio regarding two month future contracts

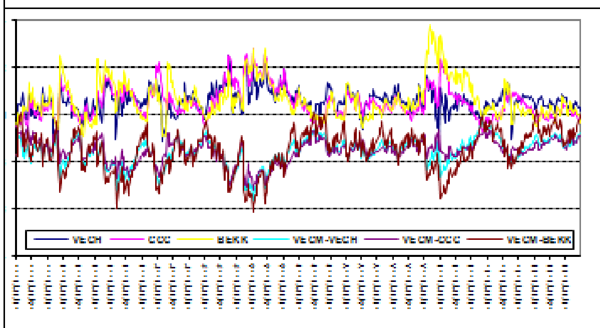


Figure 1. optimal hedge ratio regarding one month future contracts

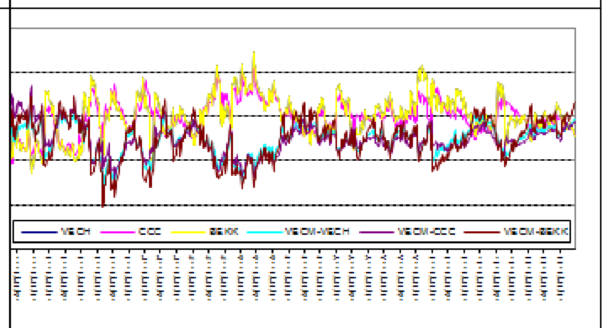


Figure 1. optimal hedge ratio regarding four month future contracts

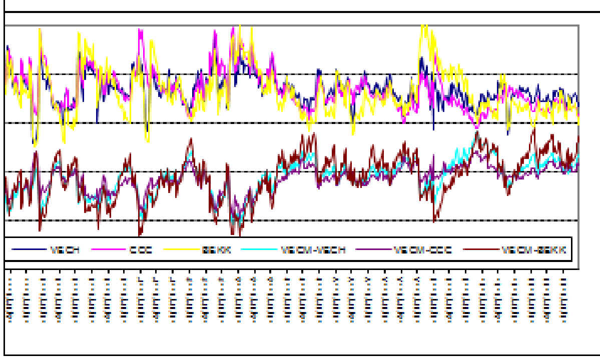
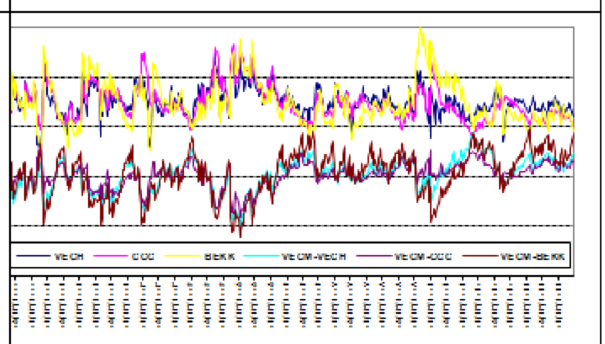


Figure 4. optimal hedge ratio regarding three month future contracts



Compare Effectiveness of Hedge Ratio

Fluctuation in hedge ratio indicates that cash goods portfolio and future contracts need a revision each week to receive optimal hedge effectiveness which is the much minimized portfolio variance.

Table 2: Compare effectiveness of hedge for one month future contract

Future contract	Model	Mean of Optimal hedge ratio	Mean of returns	Portfolio variance	Percent of effectiveness
One month	Without hedge	-------------	142/0	6/2	-----
	MD GARCH	002/1	014/0	866/0	69/66
	CCC GARCH	993/0	003/0	836/0	85/67
	BEKK-GARCH	002/1	014/0	866/0	69/66
	ECM-MD	896/0	015/0	854/0	16/67
	ECM-CCC	898/0	019/0	852/0	22/67
	ECM BEKK	898/0	015/0	855/0	11/67

To compare effectiveness of each of six sigma hedge strategies, the calculated optimal hedge ratio was used to obtain $\Delta S_t - h^* \Delta F_t$ time series variance and compared to ΔS_t which is associated to single cargo market risk without hedge. Thereafter, cash market risk is calculated in this way. This figure which is reported in percent indicates hedge effectiveness in each strategy. Tables 2-5 address evaluating effectiveness of six sigma strategies in hedge using one to four month future contracts.

Table 3: Compare effectiveness of hedge for two month future contract

Future contract	Model	Mean of Optimal hedge ratio	Mean of returns	Portfolio variance	Percent of effectiveness
two month	Without hedge	------	0.142	2.6	---
	MD GARCH	1.059	-0.004	0.866	66.09
	CCC GARCH	1.055	-0.003	0.836	65.97
	BEKK GARCH	1.066	0.013	0.866	64.07
	ECM-MD	0.844	0.018	0.854	63.11
	ECM-CCC	0.847	0.025	0.852	63.44
	ECM BEKK	0.848	0.012	0.855	63.15

Table 4: Compare effectiveness of hedge for three month future contract

Future contract	Model	Mean of Optimal hedge ratio	Mean of returns	Portfolio variance	Percent of effectiveness
Three month	Without hedge	------	0.142	2.6	---
	MD GARCH	1.100	-0.006	0.929	6427
	CCC GARCH	1.096	-0.008	0.921	64.58
	BEKK GARCH	1.097	0.008	0.981	62.28
	ECM-MD	0.807	0.020	1.043	59.88
	ECM-CCC	0.806	0.028	1.036	60.15
	ECM BEKK	0.813	0.015	1.035	60.20

Table 4: Compare effectiveness of hedge for four month future contract

Future contract	Model	Mean of Optimal hedge ratio	Mean of returns	Portfolio variance	Percent of effectiveness
Four month	Without hedge	------	0.142	2.6	---
	MD GARCH	1.135	-0.009	0.969	62.72
	CCC GARCH	1.135	-0.012	0.954	63.30
	BEKK GARCH	1.124	0.004	0.019	60.81
	ECM-MD	0.776	0.021	1.110	57.31
	ECM-CCC	0.771	0.029	1.111	57.27
	ECM BEKK	0.781	0.018	1.100	57.70

Results of data analysis shown in tables above are as follows:

In all tables, it is observed that the the basic rule of investing, that is, higher risk, higher return, is established. The highest value for returns in all tables assigned to the situation without hedge, having the highest variance. As long as futures contracts are available, the value hedge ratio for each of the strategies causes risk decreases, and thereby mean of return reduces. Hence, one month future contracts at all strategies have the highest risk and return, and the four month future contracts have the least risk and return. In each future contract, the models based on error correction have lower risk and return. The value of mean for dynamic hedge is further lower in each contract. The highest return in all the models associates to MD-GARCH and CCC-GARCH, but, the highest risk assigns to BEEK GARCH model. Here, the important point is that the results from estimation using MD-GARCH and BEKK-GARCH have the same results in one month future contracts.

In each of future contracts, the mean of dynamic hedge mean in the models based on error correction is lower than the mean of dynamic hedge ratio in simple models. This is in a way that the value of efficiency of dynamic hedge which shows percent of variance decrease rather than the case without hedge, is higher in these models. Efficiency of each model as contracts extend likewise increasing mean of dynamic hedge increases. In this regards, one month contract has the lowest efficiency and four month contracts have the highest efficiency. On the whole, VECM-CCC model has the highest efficiency for one month and two month future contracts, and VECM-BEEK model has the highest efficiency in three month and four month contracts. The important point is that adopting strategy of assuming the same position in cash and future market reports the effectiveness of hedge for one to four months future contracts equal to 68.9, 68.8, 65.19 and 63.8, where have higher efficiency rather than all the selective strategies in one to four months future contracts.

CONCLUSION

This study aims to study effectiveness of hedge on Iranian light crude oil price using one to four months future contracts, transacting in New York Stock Exchange. To calculate effectiveness of hedge unlike traditional models designed based on an estimate of optimal hedge ratio, regarding Anisotropy variance existing in traditional models, GARCH has been used to calculate the optimal hedge rate. High correlation coefficient on Iranian light crude oil price and price of one to four months future contracts indicates high hedge efficiency and strong co-integration for Iranian light crude oil price.

Estimations for future contracts in one to four months indicate that for each of the contract, the models based on error correction has lower optimal hedge ratio and higher hedge efficiency compared to simple model. The highest return on each type of contract associates to estimates of model MD-GARCH and CCC-GARCH, where the highest risk associates to BEEK-GARCH.

The results of estimate using MD-GARCH and BEKK-GARCH estimate at one month future contracts were the same and change in model did not lead to any change in results. On the whole, the highest efficiency reported in VECM-CCC model for one and two month future contracts, and VECM-BEEK model reported with highest efficiency in three and four month contracts. In general, using the hedge strategies can be helpful for one to four month contracts to cover utmost 67.85, 66.09, 64.58 and 63.30 percent risk existing in Iranian light crude oil price. Yet, adopting strategy assuming the position the same in cash and future market, effectiveness of hedge for one to four month contracts becomes 68.9, 68.8, 65.19 and 63.8 where having higher efficiency rather than the entire selective strategies in one to four month contracts.

REFERENCES

Alexander SS (1961). *Price Movements in Speculative Markets: Trend or Random Walk.*

Arshi AA (1998). *Hedge Transactions and Different Mechanisms in Oil Markets*. International affairs' National Iranian Oil Company.

Baillie RT and Myers RJ (1991). Bivariate GARCH estimation of the optimalcommodity futures hedge. *Journal of Applied Econometrics* **6**(2) 109-124.

Bollerslev T (1990). Modelling the coherence in short-run exchange rate: a multivariate generalized ARCH model. *Review of Economics and Statistics* **72**(3) 498-505.

Bollerslev T, Engle R and Nelson D (1994). ARCH models. *Handbook of Econometrics* (North Holland Press) Amsterdam 2959-3038.

Bollino CA (2007). Oil prices and the U.S. trade deficit. *Journal of Policy Modeling* **29**(5) 729-738.

Chakraborty A and Barkoulas JT (1999). Dynamic futures hedging in currency markets. *European Journal of Finance* **5**(4) 299-314.

Choudhry T (2003). Short-run deviations and optimal hedge ratio: Evidence from stock Futures. *Journal of Multinational Financial Management* **13**(2) 171-192.
Derakhshan M (2004). *Derivatives and Risk Management in the Oil Markets* (Publications International Energy Studies Institute).
Ebrahimi M and Suri A (2005). Loss from uncertainty on oil revenue on economic growth and the need for foreign exchange reserves. *Conference on Iran's Economy*.
Ederington LH (1979). The hedging performance of the new futures markets. *Journal of Finance* **34**(1) 157-170.
Engle R and Kroner K (1995). Multivariate simultaneous GARCH. *Econometric Theory* **11**(1) 122-150.
Haigh MS and MT Holt (2002). Crack spread hedging: accounting for time-varyingvolatility spillovers in the energy futures markets. *Journal of Applied Econometrics* **17**(3) 269-289.
Hamilton JD (1994). *Time Series Analysis* (Princeton University Press) Princeton.
Hans RS and Robert EW (2009). Commodity Index Investing And Commodity Futures Prices.
Jalali Naini AR and Manesh KM (2004). Study the optimal rate of hedge in the oil market. *Quarterly Energy Economics Studies* **1** 3-26.
Jalali-Naini AR and Manesh MK (2006). Price volatility, hedging and variable riskpremium in the crude oil market. *OPEC Review* **30**(2) 55-70.
Kroner KF and Sultan J (1993). Time-varying distributions and dynamic hedgeing withforeign currency futures. *Journal of Financial and Quantitative Analysis* **28**(4) 535-551.
Markowitz HM (1952). Portfolio selection. *Journal of Finance* **7**(1) 77-91.
Meneu V and Torro H (2003). Asymmetric covariance in spot-futures markets. *Journal of Futures Markets* **23**(11) 1019-1046.
Modaresi Alam Z (2004). Hedge oil prices through the government. *Economic Journal* **33** and **34** 47-38.
Modaresiuniverse V (2006). Hedge oil pricesthrough the government. *Economic Journal* 33 and 34 47-38.
Moschini G and Myers RJ (2002). Testing for constant hedge ratios in commoditymarkets: A multivariate GARCH approach. *Journal of Empirical Finance* **9**(5) 589-603.
Myers RJ (1991). Estimating time varying optimal hedge ratios on futures markets.
Park TH and Switzer LN (1995). Bivariate GARCH estimation of the optimal hedgeratios for stock index futures: a note. *Journal of Futures Markets* **15**(1) 61-67.
Phillips PCB and Perron P (1988). Testing for a unit root in time series regressions. *Biometrika* **75**(2) 335-346.